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EXAMINER	
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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/089,735
Filing Date: April 04, 2002
Appellant(s): MUELLER ET AL.

MAILED
APR 0 7 2006
GROUP 2800

EADS Deutschland GmbH, 81663 München, Germany
For Appellant

EXAMINER'S ANSWER

This is in response to the substitute appeal brief filed 10/21/2005 appealing from the Office action mailed 03/19/2004.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

Takashi et al. (JP 405049097 with English Language Abstract), 2-1993

Takashi et al. (JP 405049097 Official English Language Translation), 12-2004

Barham, R. G., "The NPL Laser Pistonphone", Journal of Low Frequency Noise and Vibration, Vol. 12, No. 2, 1993, pp. 36-38.

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1-5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Takahashi et al. (JP405049097 English language abstract only provided by Applicant as IDS document AK) in view of Barham ("The NPL Laser Pistonphone" provided by Applicant as IDS document AR).

(10) Response to Argument

Appellants argue (page 5 lines 3-9) that “there is no showing in Takashi of a high pressure adapter ‘connected to an output of the pistonphone volume’ which includes a tube formed as a λ/4 resonator having a length adapted to the excitation frequency of the pistonphone” nor “amplifier adapter” having “an expanded opening for sound proof connection to the microphone to be calibrated because the microphone of Takashi is directly connected to the pressure chamber 3.”

According to claim 1 of the instant invention:

- a high pressure adapter is connected to an output of the pistonphone volume and a high-pressure adapter includes:

- tube formed as a λ/4 resonator having a length adapted to the excitation frequency of the pistonphone to amplify the sound pressure produced in the pistonphone volume

- an expanded adapter opening with a sealing ring for a soundproof connection to said sound pressure level sensor to be calibrated.

Examiner maintains that Takashi in the figure shows a chamber 3 that generally includes the enclosed space within the body 2 and 1. The portion of this space within item 2 including the space within hole 13 may be considered to be a tube and will form a quarter wave resonator for certain frequencies depending upon the axial position of the body 2 within the body 1. A resonator is simply a hollow chamber or cavity with dimensions chosen to permit internal resonant oscillation of electromagnetic or acoustical waves of specific frequencies according to The American Heritage Dictionary of the English Language and the chamber shown in the figure fits within this definition. Below the hole 13 shown in the figure is a microphone mount 12 which is shown to be an opening expanded or increased in size from the hole 13. Air-tightness member 15 is shown in the figure within the hole 13 and is therefore considered to be substantively equivalent to an expanded adapter opening with a sealing ring as in the instant invention. The mount also serves the same intended use of providing a pressure tight and therefore to some degree a soundproof connection to microphone M which is a pressure level sensor to be calibrated (see English language abstract). As Examiner previously responded, it has been held that the recitation than an element is "adapted to" perform a function is not a positive limitation but only requires the ability to so perform. It does not constitute a limitation in any patentable sense. *In re Hutchison*, 69 USPQ 138. In this case the axial length of the chamber 3 (along with hole 13) is effectively the proper quarter wave length for "the excitation frequency of the

pistonphone to amplify the sound pressure produced in the pistonphone volume" depending on a range of frequencies that may be chosen. Takashi does not inherently or expressly place any limits on the frequencies that may be chosen and furthermore the instant invention does not positively define what frequencies are required so the reference is certainly able to perform the intended function of amplifying frequencies within some range. Appellant's assertion that the features of the high-pressure adapter where not disclosed in the Takashi reference "because the microphone of Takashi is directly connected to the pressure chamber 3" is not a compelling argument because Examiner has shown where all the limitations are taught. The directness or indirectness of the connection is not considered by the Examiner to be substantively relevant.

Appellants also allege that Examiner in the final rejection indicated "that the chamber 3 of Takashi is a high pressure adapter." Examiner made no such expressed indication but this is partly implied as will be discussed below

Appellants goes on to argue (page 5 lines 10-20) the pistonphone of the present invention is claimed as having an adjustable volume and a piston while the high pressure adapter is claimed as being connected to the output of the volume and that these feature, their interconnections and their operation are not shown in Takashi. Appellants argue that Examiner is attempting to show that chamber 3 is both the pistonphone volume and a high pressure adapter and that they cannot be both.

Examiner considers that to some degree they may be both. The instant invention includes:

- a high-pressure adapter that includes a quarter wave resonator tube and

- a pistonphone with an adjustable volume

- where the high pressure adapter is connected to the pistonphone output.

Examiner considers that Takashi shows this in the figure. Chamber 3 is an adjustable volume by virtue of the axial movement of body 2 within the body 1. The output of the sound produced by the pistonphone will pass through chamber 3 and out through hole 13 into the expanded and sealed opening at 12. The chamber 3 also has a length that may operate as a quarter wave resonator as any chamber may act as a resonator as a resonator is simply a chamber where the selected frequency may be amplified.

Appellants also argue (page 5 line 21 to page 6 line 14) Examiner's citation of *In re Hutchinson* in overcoming the limitation with respect to the "resonator having a length which is **adapted to** the excitation frequency of the pistonphone" is improper because the Hutchinson case is specifically addressed the preamble of a claim. Examiner maintains the rejection's reliance upon case law *In re Hutchison* is considered appropriate as at issue *In re Hutchison* was not the fact that the limitation following the phrase "adapted to" was in the preamble but the fact that the limitation followed the phrase "adapted to" and did not constitute a limitation in any patentable sense. The limitation at issue in that case being in the preamble was immaterial to the decision.

Appellants further argue the *In re Venezia* decision held that "adapted to" functions as a limitation and that Examiner must consider those structural limitations that follow. Examiner agrees and Examiner did consider the limitations. However, Examiner continues to maintain that the resonator having a length which is "**adapted to**

the excitation frequency of the pistonphone" does not serve to further limit the structure beyond a requirement that resonator have a length which Takashi discloses. Moreover, the Takashi length is adjustable so it is adaptable in the manner of the intended use of the device in the instant invention for a range of frequencies.

Finally, Appellants argue (page 6 lines 15-20) Takashi does not disclose that the amplifier adapter has an expanded opening for a sound proof connection to the microphone to be calibrated and "Takashi is not a high pressure adapter because the chamber 3 is that portion which is required to form the pistonphone so it cannot be both the pistonphone volume and the adapter connected to the pistonphone.

Examiner maintains that bodies 1 and 2 of Takashi include all the portions of a "high-pressure adapter" claimed by Appellants. Chamber 3 is a tube-like formation within the bodies serving to inherently function as a resonator as a resonator is simply a chamber that may amplify sound by its length. Mount 12 is an expanded opening in the body 2 and serves the intended use of providing an airtight (therefore to some degree sound proof at least in the same manner as disclosed by Appellant) to the microphone M to be calibrated. As previously stated, the bodies 1, 2 with chamber 3 are indeed to some extent both the pistonphone volume and adapter connected to the pistonphone. Likewise, one could make the argument that Appellants invention shown in figure 1 of the disclosure having a continuous volume at items 5 and 6 are both a pistonphone volume and adapter connected to the pistonphone.

From page 6 line 20 to page 7 line 2, Appellant recite features of the instant invention but provide no argument against the prima facie case presented by the Examiner so no answer is presented in reply.

Appellants also state that Examiner's reliance on Barham as a secondary reference in rejection under 35 USC § 103 adds nothing towards meeting the claimed limitations. However, Examiner considers this was necessary to teach a pistonphone capable of selected excitation frequencies, which was not expressly, nor in Examiner's view inherently, disclosed by Takashi.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

cdg

CHARLES GARBER
PRIMARY EXAMINER

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Charles Garber, Examiner
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PTO 05-1000

CY=JA DATE=19930226 KIND=A
PN=05-049097

LARGE SOUND PRESSURE PROVISION DEVICE FOR MEASURING AND CALIBRATING MICROPHONE CHARACTERISTIC

[Mikrohon kokusei sokutei/kouseiyou no daionatsufukasochi]

Takashi Hashizume, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. December 2004

Translated by: FLS, Inc.

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APPLICANT	(71):	Ono Sokuki Inc.
TITLE	(54):	LARGE SOUND PRESSURE PROVISION DEVICE FOR MEASURING AND CALIBRATING MICROPHONE CHARACTERISTIC
FOREIGN TITLE	[54A]	Mikrohon kokusei sokutei/kouseiyou no daionatsufukasochi

[Claim(s)]

[Claim 1] Large sound pressure provision device for measuring and calibrating microphone characteristic comprising (1) a pressure chamber varying means consisting of a casing which demarcates a pressure chamber by freely adjusting the volume and a piston reciprocating with a cylinder hole opened toward the pressure chamber and the operation of a cam, and (2) a microphone mount in which a measured microphone is mounted to the casing in a way of facing the pressure chamber with air-tightness member.

[Claim 2] Large sound pressure provision device for measuring and calibrating microphone characteristic according to Claim 1, wherein said casing is configured of two cup shaped main bodies screwed directly and indirectly.

[Detailed Description of the Invention]

[0001] [Industrial Application]

This invention relates to the large sound pressure addition equipment for microphone characteristic measurement and calibrating.

[0002] [Description of the Prior Art]

Distortion-rate property in large sound pressure is one of the acoustic features of a microphone. To measure and calibrate the distortion-rate, the large sound pressure of about 140 dB is applied to a standard microphone and a measured microphone, and the properties of both in that case are compared. In the prior art, the

following means are taken as a means to apply the large sound pressure.

[0003] A microphone is installed at a predetermined site in the front of a speaker connected to a synthesizer or the like through a power amplification device in an anechoic chamber, and large sound is generated from a speaker by the synthesizer.

[0004] [Problem(s) to be Solved by the Invention]

As a means to apply the large sound pressure of about 140dB to a microphone using a loudspeaker in the above-mentioned prior art, an anechoic chamber is required. In addition, the equipment itself must be configured as large-scale. This invention offers a small and simple large sound pressure addition means.

[0005] [Means for Solving the Problem]

To solve the problem described above, this invention provides a large sound pressure provision device for measuring and calibrating microphone characteristic comprising a pressure chamber varying means consisting of a casing configured of two cup shaped main bodies screwed directly and indirectly for demarcating a pressure chamber by freely adjusting the volume and a piston reciprocating with a cylinder hole opened toward the pressure chamber and the operation of a cam, and a microphone mount part in which a measured microphone is mounted to the casing in a way of facing the pressure chamber with air-tightness member.

[0006] [Function]

The volume of a pressure chamber can be adjusted by providing relative rotations of the two cup-like bodies connected with screws, allowing said bodies to mutually move forward and backward. Then, the volume of a pressure chamber is set to a predetermined value. The microphone connected to the external measuring instrument is air-tightly mounted to a microphone mount part and is positioned to face to a pressure chamber.

[0007] Then, a piston provides reciprocation movements of a predetermined stroke by periodic operation of a cam. Since the volume V of the pressure chamber is increased in a range of ΔV with the reciprocation at a prescribed stroke of a piston caused by the periodic operation of the cam, the inner pressure in the pressure chamber is increased/decreased in a range of $\Delta = K \times (\Delta V/V)$ periodically.

[0008] As a result, a sound pressure ΔP adjusted optionally is exerted to the microphone. V is adjusted by relative rotation of two cup-like bodies as mentioned above, and change of ΔV is correctly prescribed by the cam. Therefore, the sound pressure of arbitrary magnitude can be applied to a microphone. Thus, the output generated by applying the sound pressure of arbitrary magnitude to a microphone is detected by an external measuring instrument to allow measurement of large sound pressure property.

[0009] [Example]

The following will explain large sound pressure addition equipment for measuring and calibrating the microphone property of this invention according to a drawing. As shown in Fig. 1, the outside cup-like body **1** and the inside cup-like body **2** are positioned nest-like to configure a cylindrical pressure chamber **3**. In this case, screws are engraved on each of the inner peripheral surface of the outside cup-like body **1**, and the outer peripheral surface of the inside cup-like body **2**, thus allowing thread part **4** of the inner face of the outside cup-like body 1 and the thread part **5** of the outer face of the inside cup-like body **2** to be screwed. Note that the outside cup-like body **1** and the inside cup-like body **2** may be arranged to have the same diameter, thereby being joined by other screw-thread rings.

[0010] A protruding part **6** (for example, cylindrical shape protrusion) protruding toward the inner direction is formed in the center section of the bottom of the outside cup-like body **1**. While a cam room **8** where a plate cam **7** is held in the axial circumference of the protrusion **6**, being arranged to freely rotate, is formed in the center section of the protrusion **6**, the revolving shaft **9** of the plate cam **7** penetrates the core of the protrusion **6** and is connected to a motor (not shown) positioned at the exterior of the outside cup-like body **1**. Furthermore, the cylindrical holes **10**, **10** penetrating into the pressure chamber **3** from the cam room **8** in the diameter

direction, wherein a free piston **11** of the cross section **A** is fitted in each cylindrical hole **10**, and the inner end face of each free piston **11** is contacted by the cam side of a plate cam **7**.

[0011] The cam face of the plate cam **7** is arranged to provide a simple harmonic motion of stroke S in a cycle of 2n per rotation to a free piston **11**. The cylinder piston system may be a single unit, other operational systems, or the like.

[0012] The outer microphone mount hole **12** and inner connection hole **13** form steps **14** from the outer area toward the pressure chamber **3** and connected/opened on the coaxial line at the center area of the bottom of the inside cup-like body **2**. Also, an O ring **15** is attached in the inner surface of the microphone mount hole **12**.

[0013] The following explains the operation and function of the large sound pressure addition equipment. The volume of the pressure chamber **3** is adjusted by relatively rotating the outside cup-like body **1** and inside cup-like body **2** connected with screws (screws **4**, **5**) for providing the forward and backward movements to the inside cup-like body **2** against the outside cup-like body **1**. Thus, the volume of the pressure chamber **3** is set to the predetermined value **V**.

[0014] The microphone LARGE SOUND PRESSURE PROVISION DEVICE FOR MEASURING AND CALIBRATING MICROPHONE CHARACTERISTIC connected to the external measurement instrument (not shown) is fitted in the microphone mount hole **12**. Hence, when the outer peripheral face of

microphone M engages with the O ring **15**, the air-tightness of the pressure chamber **3** is maintained.

[0015] Then, by rotating the revolving shaft **9** at a predetermined rotational frequency using a motor, the plate cam **7** rotates, thereby making the free pistons **11** and **11** produce a simple harmonic motion of stroke **S** at a fixed frequency.

[0016] Then, since the volume **V** of the pressure chamber **3** is fluctuated in the range of $\Delta V=2AS$ at a fixed frequency by the simple harmonic motion of free pistons **11** and **11**, the internal pressure in the pressure chamber **3** is fluctuated in the range of $\Delta P=K\times(\Delta V/V)$ at a fixed frequency.

[0017] Consequently, the sound pressure of ΔP is added to the diaphragm of microphone **M**. V is adjusted by relative rotation of the outside cup-like body 1 and the inside cup-like body 2 as mentioned above, while the change of S (i.e., ΔV) is correctly prescribed by the plate cam **7**. Therefore, the sound pressure of the arbitrary magnitude can be applied to the diaphragm of microphone **M**.

[0018] Thus, the sound pressure of arbitrary magnitude is applied to microphone **M**, hence allowing the large sound pressure property to be measured by detecting the output with an external measuring instrument (not shown).

[0019] [Effect of the Invention]

The large sound pressure addition equipment for microphone property measurement and calibration of this invention is simply

structured and can apply a freely adjustable arbitrary sound pressure to measuring microphone arbitration. The sound pressure prescribed by the configuration of a rotating cam has high reproducibility. Moreover, when operating the equipment, an anechoic chamber and vibration/sound proofing device are not required.

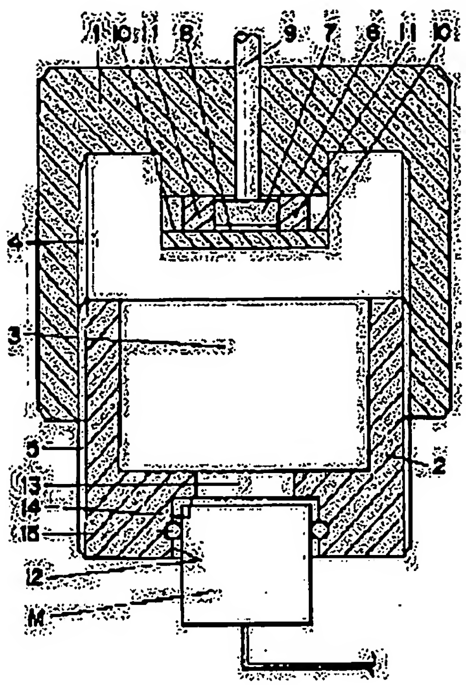
[Brief Description of the Figures]

[Figure 1] Sectional view of the large sound pressure addition equipment for microphone property measurement and calibration used in the example of this invention.

[Description of Notations]

1...Outside Cup-like Body; 2...Inside Cup-like Body; 3...Pressure chamber; 4...Five Thread part; 6...Lobe; 7...Plate Cam; 8...Cam Room; 9...Revolving Shaft; 10...Cylinder Hole; 11...Free Piston; 12...Microphone Wearing Hole; 13...Free Passage Hole; 14...Step;
15...O Ring

Figure 1



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PATENT ABSTRACTS OF JAPAN

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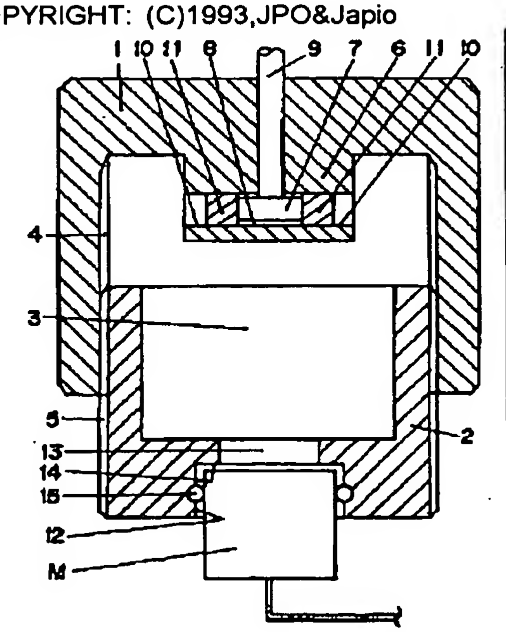
(54)**LARGE SOUND PRESSURE PROVISION DEVICE FOR MEASURING AND CALIBRATING MICROPHONE CHARACTERISTIC**

(57)Abstract:

PURPOSE: To realize the small sized and simple sound pressure provision device for measuring and calibrating the microphone characteristic not requiring installation such as an anechoic chamber.

CONSTITUTION: A large sound pressure provision device is provided with a pressure chamber varying means consisting of a casing in which two cup shaped main bodies 1,2 are screwed directly indirectly to partition a pressure chamber 3 freely adjusting the volume, of a piston 11 reciprocating with a cylinder hole 10 opened toward the pressure chamber and the operation of a cam 7, and with a microphone mount part 12 in which a measured microphone is mounted to the casing in a way of facing the pressure chamber with air-tightness member 15. Since the volume V of the pressure chamber is increased in a range of ΔV=2AS with the reciprocation at a prescribed stroke of a piston caused by the periodic operation of the cam, the inner pressure in the pressure chamber is increased/decreased in a range of Δ=K×(ΔV/V) periodically, resulting that a sound pressure ΔP adjusted optionally is exerted to the microphone.



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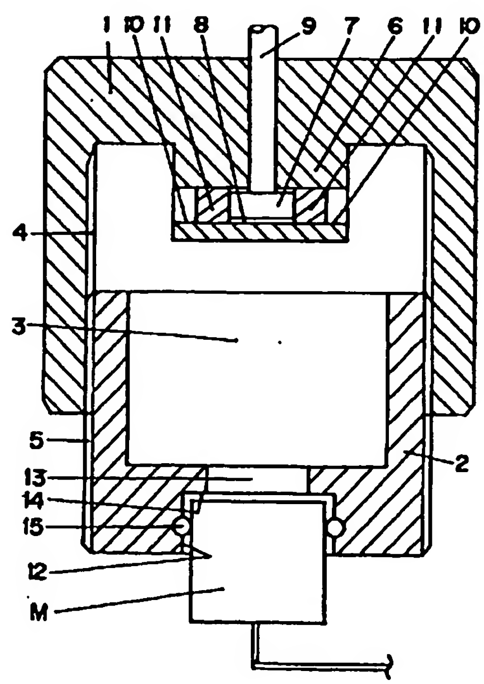
最終頁に続く

(54)【発明の名称】　マイクロホン特性測定・校正用の大音圧付加装置

(57)【要約】

【目的】　無響室等の設備を要しない小形で簡便なマイクロホン特性測定・校正用のを提供するものである。

【構成】　大音圧付加装置は、2つのカップ状本体1，2が直接・間接に螺合されて容積調節自在に圧力室3を画定するケーシング、圧力室に向って開口するシリンダ孔10とカム作動7で往復動するピストン11から成る圧力室変圧手段、及び圧力室に面するよう被測定マイクロホンが気密性15をもってケーシングに装着されるマイクロホン装着部12から構成されている。カムの周期的な作動により生じるピストンの所定ストロークSの往復動により圧力室の容積Vは、ΔV＝2ASの範囲で増減するので、圧力室内の内圧は、周期的にΔP＝K×（ΔV／V）の範囲で増減し、その結果、マイクロホンには、任意に調節されたΔPの音圧が加わる。



【特許請求の範囲】
【請求項1】　容積調節自在に圧力室を画定するケーシング、圧力室に向って開口するシリンダ孔とカム作動で往復動するピストンから成る圧力室変圧手段、及び圧力室に面するよう被測定マイクロホンが気密性をもってケーシングに装着されるマイクロホン装着部から構成されたマイクロホン特性測定・校正用の大音圧付加装置
【請求項2】　ケーシングが２つのカップ状本体が直接・間接に螺合されて構成された請求項１に記載のマイクロホン特性測定・校正用の大音圧付加装置
【発明の詳細な説明】
【０００１】
【産業上の利用分野】この発明は、マイクロホン特性測定・校正用の大音圧付加装置に関する。
【０００２】
【従来の技術】マイクロホンの音響特性の一つに大音圧における歪率特性があり、その歪率特性を測定・校正するためには、標準マイクロホン及び被測定マイクロホンに１４０ｄＢ位の大音圧を加え、その場合の両者の特性を比較して被測定マイクロホンの歪率特性を測定するのであるが、その大音圧を加える手段として、従来の技術においては次のような手段がとられている。
【０００３】無響室中において、パワーアンプを介して例えばシンセサイザに接続されたスピーカの前面所定位置にマイクロホンを設置して、シンセサイザによりスピーカから大音響を発生させるのである。
【０００４】
【発明が解決しようとする課題】上記の従来の技術におけるスピーカを用いてマイクロホンに１４０ｄＢ位の大音圧を加える手段は、無響室も必要であり、装置自体もかなり大規模なものとなる。この発明は、小形で簡便な大音圧付加手段を提供するものである。
【０００５】
【課題を解決するための手段】この発明のマイクロホン特性測定・校正用の大音圧付加装置は、２つのカップ状本体が直接・間接に螺合されて容積調節自在に圧力室を画定するケーシング、圧力室に向って開口するシリンダ孔とカム作動で往復動するピストンから成る圧力室変圧手段、及び圧力室に面するよう被測定マイクロホンが気密性をもってケーシングに装着されるマイクロホン装着部から構成されている。
【０００６】
【作用】ねじ結合されている２つのカップ状本体を相対回転し、互に進退させることにより、圧力室の容積は調節される。そこで、圧力室の容積を所定値にセットする。そして、外部の測定器に接続されたマイクロホンは、マイクロホン装着部に気密性をもって装着され、圧力室に面する。
【０００７】そこで、カムの周期的な作動によりピストンは、所定ストロークの往復動をする。すると、ピストンの往復動により圧力室の容積Ｖは、周期的にΔＶの範囲で増減するので、圧力室内の内圧は、周期的にΔＰ＝Ｋ×（ΔＶ／Ｖ）の範囲で増減する。
【０００８】その結果、マイクロホンには、ΔＰの音圧が加わったことになる。Ｖは、上記のように２つのカップ状本体の相対回転で調節され、ΔＶの変化は、カムにより正確に規定される。従って、マイクロホンには、任意の大きさの音圧を加えることができる。このようにしてマイクロホンに任意の大きさの音圧が加えられ、その出力を外部の測定器で検出することによりその大音圧特性が検測される。
【０００９】
【実施例】この発明の実施例におけるマイクロホン特性測定・校正用の大音圧付加装置を図面に従って説明する。図１に示すように、外側カップ状本体１と内側カップ状本体２とが対向して入れ子状となって円筒形の圧力室３が形成されるのであるが、外側カップ状本体１の内周面及び内側カップ状本体２の外周面の夫々にはねじが刻設され、外側カップ状本体１の内周面のねじ部４と内側カップ状本体２の外周面のねじ部５とが螺合している。なお、外側カップ状本体１と内側カップ状本体２とは、同径で、他のねじ環で結合されてもよい。
【００１０】外側カップ状本体１の底部の中央部には、内方に向って突出部６（例えば円筒形突出部）が形成され、突出部６の中央部には、板カム７が突出部６の軸線回りに回転自在に収容されたカム室８が形成されると共に、板カム７の回転軸９は、突出部６の中心を回転自在に貫通して外側カップ状本体１の外部に設けられたモータ（図示しない）に結合されている。更に、カム室８から圧力室３に直径方向に貫通したシリンダ孔10，10が穿設され、各シリンダ孔10には、断面積Ａのフリーピストン11が嵌装され、各フリーピストン11の内端面は、板カム７のカム面に当接されている。
【００１１】板カム７のカム面は、１回転で２ｎ周期のストロークＳの単振動をフリーピストン11に与えるカム形状である。シリンダ・ピストン機構は、単一のもの、他の作動機構のもの等、適宜のものでもよい。
【００１２】内側カップ状本体２の底部の中央部には、外部から圧力室３へと外側のマイクロホン装着孔12と内側の連通孔13とが段部14を形成して同軸線で連通開口しており、マイクロホン装着孔12の内周面には、Ｏリング15が嵌着されている。
【００１３】大音圧付加装置の操作・作用について述べると、ねじ結合（ねじ部４・ねじ部５）されている外側カップ状本体１と内側カップ状本体２とを相対回転して外側カップ状本体１に対し内側カップ状本体２を進退させることにより、圧力室３の容積は調節される。そこで、圧力室３の容積を所定値Ｖにセットする。
【００１４】そして、外部の測定器（図示しない）に接続さたマイクロホンＭは、マイクロホン装着孔12に嵌装

され、マイクロホンMの外周面がOリング15に係合することにより圧力室3の気密性は保たれる。

【0015】そこで、モータにより回転軸9を所定回転数で回転駆動すると、板カム7が回転し、それに応じてフリーピストン11，11は、一定周波数で対向したストロークSの単振動運動をする。

【0016】すると、フリーピストン11，11の単振動運動により圧力室3の容積Vは、一定周期でΔV＝2ASの範囲で増減するので、圧力室3内の内圧は、一定周期でΔP＝K×（ΔV／V）の範囲で増減する。

【0017】その結果、マイクロホンMのダイヤフラムには、ΔPの音圧が加わったことになる。Vは、上記のように外側カップ状本体1と内側カップ状本体2とを相対回転で調節され、S、即ちΔVの変化は、板カム7により正確に規定される。従って、マイクロホンMのダイヤフラムには、任意の大きさの音圧を加えることができる。

【0018】このようにしてマイクロホンMに任意の大きさの音圧が加えられ、その出力を外部の測定器（図示しない）で検出することによりその大音圧特性が検測される。

【0019】

【発明の効果】この発明のマイクロホン特性測定・校正用の大音圧付加装置は、簡便な構造で、調節自在の任意の音圧を被測定マイクロホンに加えることができ、音圧は、回転カムの形状で規定され再現性が高い。又、装置の使用に際し、無響室及び防振・防音設備が必要ではない。

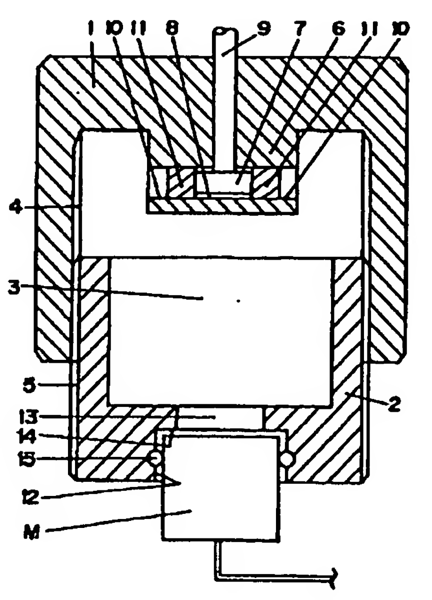
【図面の簡単な説明】

【図1】この発明の実施例におけるマイクロホン特性測定・校正用の大音圧付加装置の断面図である。

【符号の説明】

1 外側カップ状本体
2 内側カップ状本体
3 圧力室
4，5 ねじ部
6 突出部
7 板カム
8 カム室
9 回転軸
10 シリンダ孔
11 フリーピストン
12 マイクロホン装着孔
13 連通孔
14 段部
15 Oリング

【図1】



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The NPL Laser Pistonphone

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1. Introduction

The last decade has seen significant development in the capabilities of acoustical measuring instruments. Alongside the rapidly improving technology, there has been a growing need to demonstrate the quality of acoustical measurements themselves. In the UK, this can be achieved by gaining accreditation from a body such as the National Measurement Accreditation Service (NAMAS). However, regardless of whether formal accreditation is deemed necessary, it is good practice to follow the requirements of organisations such as NAMAS. One important aspect is to ensure that measurements are ultimately traceable to a primary standard. Without this, the measurement has no basis and its accuracy cannot be assessed. In acoustics the primary quantity is sound pressure and the standard is realised in terms of the sensitivity of a microphone. It is the task of the National Physical Laboratory (NPL) to maintain this standard for the UK and to provide access to it through calibration services.

Laboratory standard microphones[1] can be calibrated with greatest accuracy by the reciprocity method using a closed acoustic coupler[2]. The method is now well established for one-inch and half-inch microphones and is used up to a frequency of 20 kHz. There is however a lower limit to the frequency range, which is set by how well a pair of microphones can be coupled by a small vented volume. Consequently, reciprocity calibrations are not normally performed below 63 Hz at NPL. The assumptions and practicalities of the reciprocity method also limit the types of devices that can be calibrated. To provide standards below 63 Hz and to enable a wider selection of microphone types to be calibrated, a special pistonphone has been developed at NPL.

The so-called laser pistonphone is an absolute calibration device for measurement microphones. It operates at variable frequency and sound pressure level settings, the latter being calculable from laser interferometric measurements, from which the device derives its name.

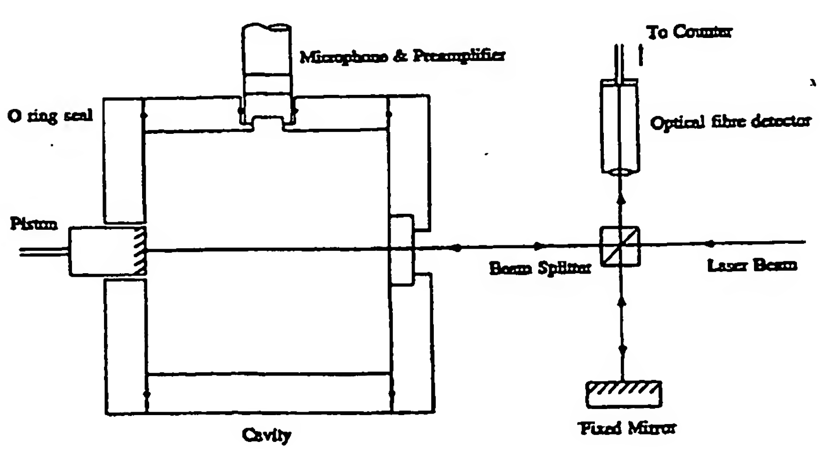

Figure 1. Layout of the laser pistonphone.

2. The Laser Pistonphone

The laser pistonphone is similar in principle to commercially available pistonphones in that the sinusoidal motion of a small piston generates a uniformly distributed acoustic pressure within a closed cavity. The laser pistonphone has a cylindrical cavity which is 60 mm in length and diameter, with a 15 mm diameter piston housed in one end face and a microphone port located halfway along the length of the cylinder. With this geometry, illustrated in Figure 1, operation to a maximum frequency of 250 Hz is possible with less than ±0.03 dB uncertainty due to acoustic pressure non-uniformity in the cavity. The laser pistonphone is however primarily a low-frequency device. The lower frequency limit of operation is governed by the amount of pressure leakage that occurs around the microphone seal and from the gap between the piston and its guide. The limit is determined by measuring the time constant of the static pressure decay resulting from a step input to the cavity, and is in the range 0.5 Hz to 1 Hz.

The sound pressure can be calculated from the following equation, which is derived from the adiabatic gas law.

$$p = \frac{\gamma P_0 \pi d^2 \delta x}{4V}$$

where γ is the ratio of principal specific heats for air, P_0 is the atmospheric pressure, d is the diameter and δx the displacement of the piston and V the volume of the cavity. A simple Michelson laser interferometer, employing fringe counting, is used to measure the displacement of the piston, which is of the order of 1 mm. Sound pressure levels are typically in the range 80 dB to 130 dB, however this can be increased to 160 dB when necessary.

The typical sound pressure level is sufficiently high for measurements not to be affected greatly by external acoustic noise, but vibration is a potential problem. It is necessary for the pistonphone and interferometer to be rigidly fixed to a common structure that eliminates relative movement between these two components. This would otherwise cause errors in the determination of the cavity acoustic pressure. Further steps are taken to reduce mechanical vibration that might be picked up by the test microphone and the whole assembly is mounted on an anti-vibration table.

3. Applications of the Laser Pistonphone

There are several potential applications for a device such as this. So to allow it to be as versatile as possible the laser pistonphone was designed so that the main acoustic cavity is interchangeable. Several cavities have been manufactured to perform different tasks and others can be produced as applications arise.

3.1 Absolute calibration of microphones

Two cavities, each with a very well defined shape and volume have been produced for determining the pressure sensitivity of laboratory standard microphones. The open-circuit output voltage of the microphone is measured by the insert-voltage method and the acoustic pressure in the cavity is calculated from the measured displacement of the piston. This allows the pressure sensitivity of the microphone (the quotient of the above quantities, expressed in dB re 1 V/Pa) to be determined. The uncertainty in the calibration is ±0.05 dB for frequencies between 63 Hz and 250 Hz, increasing ±0.2 dB at 10 Hz and ±0.3 dB at 1 Hz. The major components of this uncertainty are uncertainties in the volume of the cavity, the diameter of the piston, and at very low frequencies, the pressure leakage from the cavity.

This is an important application that benefits many types of low-frequency sound measurement. By providing a means of absolute calibration, the laser pistonphone allows the primary standard for sound pressure to be extended to 1 Hz.

3.2 Calibration by comparison

Some types of measurement microphones pose calibration difficulties and the laser pistonphone can address this problem over its working frequency range. Measurement microphones can be calibrated by comparison with a reference microphone in a cavity that has two ports. This allows the two microphones to be exposed to the same acoustic pressure simultaneously. This cavity can be adapted to accommodate most

commercially available microphone types. Calibration by comparison achieves higher accuracy than absolute calibration in the laser pistonphone for a non-standard microphone because the microphone itself may add an ill-defined and uncertain volume to the cavity.

Comparison calibrations have an uncertainty of ±0.06 dB at moderate frequencies, increasing to ±0.2 dB at 15 Hz and further still at lower frequencies. Although the acoustic pressure need not be determined in this application and does not therefore contribute to the uncertainty in the calibration, the uncertainty in the sensitivity of the reference microphone significantly influences the overall accuracy. The reference microphone itself may have to be calibrated in the laser pistonphone, by the absolute method above, if the frequencies of interest for the test microphone lie below 63 Hz.

3.3 Other Applications

As well as having applications in calibration, the laser pistonphone provides for a number of other uses. It can be used to study the low-frequency performance of microphones: with only the diaphragm exposed the pressure response can be studied and by inserting the whole microphone capsule into the cavity, thus exposing the equalisation vent, the free-field response can be measured. Using a two-port cavity, the relative phase responses of a pair of microphones can be measured. The relative phase response is important in sound intensity measurement applications. The laser pistonphone has also provided an independent check on the accuracy of the reciprocity method of calibration. Preliminary measurements have shown agreement within ±0.05 dB in the frequency range 63 Hz to 250 Hz.

4. Conclusions

The laser pistonphone enables the frequency range for which sound pressure standards are held to be extended down to 1 Hz. It allows all types of microphones to be calibrated in the range 1 Hz to 250 Hz, either by absolute means or by comparison, depending on the type of microphone. In addition a number of other facilities are provided for and the range of applications can be extended whenever necessary simply by designing appropriate cavities to perform the required task.

The laser pistonphone is now operational and available for use in measurement services from NPL.

5. References

1. International Electrotechnical Commission 1992. Measurement microphones Part 1. Specification for laboratory standard microphones. IEC 1094 Part 1.

2. International Electrotechnical Commission 1992. Measurement microphones Part 2. Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique. IEC 1094 Part 2.